AN INEXPENSIVE, HIGH-EFFICIENCY TULLGREN EXTRACTOR FOR SOIL MICROARTHROPODS[1]

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ABSTRACT

An inexpensive Tullgren-type extractor employing steep temperature and humidity gradients was constructed inside a refrigerator-sized environmental chamber and a used household refrigerator. The extractor has proven to be highly efficient.

Key Words: Soil arthropods, extractor, Acarina, Insecta.

Soil ecosystems support large populations of microarthropods — principally mites and collembolans — which contribute to the processes of breakdown and decomposition of dead organic matter. Sampling techniques for these arthropods usually involve extracting them from soil cores using Berlese- or Tullgren-type funnels. Large funnels heated by light bulbs are still a satisfactory and simple means for qualitative collections. For population studies, simple funnels are unsatisfactory because the efficiency of extraction for most arthropod groups is extremely low. Many modifications have been suggested to increase the extraction efficiency and improve the funnels as quantitative sampling tools. The most important of these appear to be the combining of small funnels into groups and various techniques for establishing steep temperature and humidity gradients within the samples. Steep gradients require that the bottom of the sample be cooled while the top is heated. Cold water (Southwood 1966) and cold air (Edwards and Fletcher 1969) have been used. Cooling systems are often elaborate, relatively expensive, and require substantial space.

The extractor we describe here has been constructed inside a refrigerator-sized environmental chamber and a standard household refrigerator. Both chambers provide ample cooling to produce a temperature gradient of about 25 C within a 2-inch soil core, yielding extraction efficiencies comparable to other high-gradient devices reported in the literature. The complete cost of the extractor was less than $40 when a used (second hand) refrigerator was utilized.

DESCRIPTION AND OPERATION OF EXTRACTOR

The funnel units were designed for the extraction of soil cores 5 cm in diameter. The sampling tool which we use is a commercially available soil core sampler (Art's Machine Shop, American Falls, Idaho) which takes cores to a depth of 2.5 or 5.0 cm, depending on the size of the core container. The samples emerge from the sampling tool enclosed in open-ended aluminum sampling cylinders. The samples are left intact and are placed in the extractor in an inverted position.

Two extractors have been constructed — one in a refrigerator-sized

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environmental chamber (Precision Scientific Co., Model 805) and the other in a used refrigerator. Fifteen samples can be processed simultaneously in the refrigerator and twenty in the environmental chamber. Core samples are inserted through 5-cm dia. openings in plywood baffles and rest directly on the steel-grating refrigerator shelf (Figure 1). The plywood baffles are 1.3 cm thick and are elevated 1.3 cm above the refrigerator shelf. A piece of 2 mm mesh wire gauze placed under the sample core reduces the amount of loose soil and debris which falls into the collecting vial (Figure 2).

The heat source above each sample consists of a 7.5 watt light bulb mounted in a 12-oz aluminum beverage can (6.5 cm dia. x 12.2 cm high) open at both ends. The can is centered over the core sample container and is held loosely in position between finishing nails driven into the plywood baffle. The light bulbs are on a standard Christmas tree string wired in parallel. One bulb is suspended in each can by pulling the light cord even with the top of the can and taping the cord to the sides of the can with scotch tape. A piece of household aluminum foil is pressed over the top of the can to form a reflector and minimize heat loss to the chamber air. The light source thus applies heat to the upper body of the core sample. The plywood baffle shields the bottom half from the heat and allows the bottom of the sample to be cooled by the refrigerated air.

The collecting apparatus beneath the sample consists of a 5-dram glass vial with a soft plastic stopper connected to a 65 mm top dia. plastic powder funnel. The stem of the funnel is forced through a hole cut in the stopper of the vial, and the stopper is left permanently in place. Vials can be easily attached or removed. The funnel is fastened to the refrigerator shelf by looping rubber bands from the shelf to opposite sides of the funnel. Ethyl alcohol solution (80%) is used as an attractant (Edwards and Fletcher 1969) and preservative in the collecting vials.

With the environmental chamber at its minimum temperature setting (5 C) and with 10 funnel lights in operation, the chamber maintained an ambient temperature (measured at the top of the chamber) between 15 and 20 C. The bottoms of the cores were cooler than ambient (Table 1). When all 20 funnel lights were used in the chamber, it was necessary to direct wind from an electric fan across the heat sink at the back of the environmental chamber. Table 1 gives the temperature regime measured at the top and bottom of a single core sample during a 10-day period. A gradient of 15 C was attained after 15 minutes and of 23 C after 3 hours; a gradient of approximately 25 C was maintained thereafer.

Table 2 gives the numbers of arthropods collected from samples of mixed hardwood forest floor and extracted for 10 days. The results indicate an average of approximately 650 anthropods per core sample. From the sample area of the core sampler (19.6 cm^2), this number can be extrapolated to 3.3×10^5 arthropods per m^2. This estimate is of the same order of magnitude as other estimates of soil-litter microarthropod populations: 1.02×10^5 for pine mor (Crossley and Bohnsack 1960), 3.37×10^5 for beech mor (Van der Drift 1951), 2.64×10^5 for pasture (Salt *et al.* 1948), and 2.59×10^5 for an old field (Hairston and

Figure 1. Interior of refrigerator with light sources, funnels and collecing vials in place.

Byers 1954). Thus the results from our extractor compare favorably with others suggesting that the device is comparably efficient.

Effect of Light Bulb Color on Extraction Efficiency

The use of Christmas tree lights in the extractor provided an opportunity to investigate the effectiveness of different colors of light on extraction efficiency. We have found no previous reports of the influence of color of light or intensity in Tullgren funnel operation. Some microarthropods (larvae of Trombidiidae and Trombiculidae) are known to be attracted towards light, so that light color or intensity could be an important

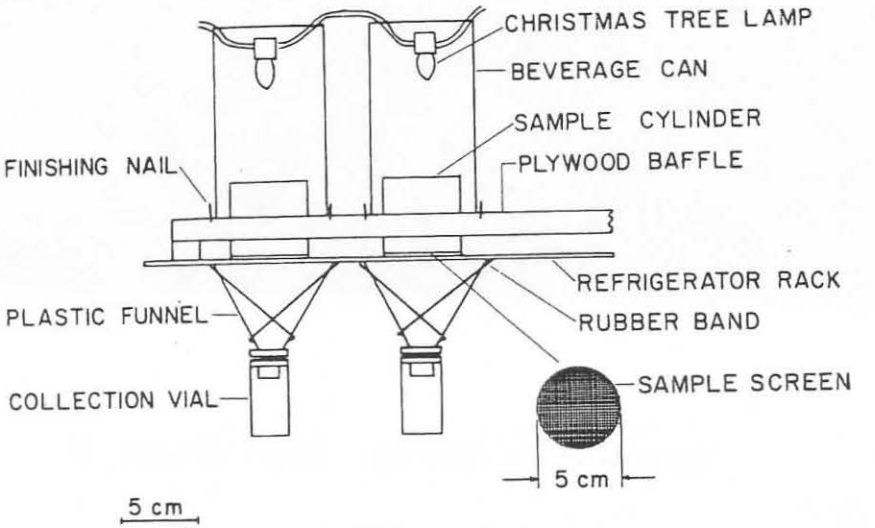

Figure 2. Side view of high efficiency extractor.

factor in extraction efficiency. To examine the effect of color of light, we collected 20 soil cores from a small (40 x 40 cm) plot in a mixed hardwood forest on the Horticulture Farm, University of Georgia Campus, Athens, Georgia, on January 15, 1969. Three samples each were extracted under light bulbs colored blue, green, yellow, red, white or clear. Two samples were extracted without light or heat. Color of bulb was

Table 1. Temperatures recorded at top and bottom of a sample core during the extraction process (YSI thermistor thermometer; sample extracted under red light bulb).

TIME	TEMPERATURE (°C)			
	Top of Core	Bottom of Core	Gradient	Ambient in Chamber
Start	23	23	0	23
15 min	37	22	15	
33 hr	44	21	23	22
18 hr	42	17	25	20
27 hr	32	16	16	18
37 hr	38	11	27	15
day 4	40	14	26	17
day 5	39	14	25	17
day 6	39	13	26	16
day 7	38	13	25	16
day 8	39	14	25	17
day 9	39	13	26	17
day 10	40	13	27	16

Table 2. Mean numbers of arthropods per soil core, extracted under various colors of light bulbs. Values are means of 3 samples (2 samples only for yellow and no bulb extractions).

Taxon	Color of Bulb						
	Clear	White	Blue	Green	Red	Yellow	No Bulb
ACARINA							
Mesostigmata	5.7	19.6	11.3	12.0	13.0	20.0	7.0
Prostigmata	160.0	176.3	158.0	153.3	172.7	160.5	72.5
Oribatei	194.3	580.0	411.3	405.3	488.7	394.5	109.0
INSECTA							
Collembola	29.6	65.3	41.6	47.0	27.3	35.5	8.0
Other	8.0	10.3	7.0	11.0	21.7	20.0	2.5
Other Arthropoda	6.0	5.3	3.0	3.3	7.6	9.0	0.5
Total per sample	403.6	856.8	632.2	631.9	730.9	639.5	199.5

assigned at random in the extractor. After ten days samples were removed and sorted under a binocular dissecting microscope at a magnification of 45X. Each sample was searched with a light and a dark background.

Table 2 presents the results of samples extracted under different colors of light bulbs. The various colors produced essentially similar results, and all yielded more arthropods than the cores extracted without bulbs. The samples extracted under clear bulbs produced fewer total arthropods, fewer Mesostigmata, and fewer Oribatei than did samples extracted under colored or white bulbs. Differences were statistically significant ($P<0.05$) only for the Mesostigmata however. The temperature attained at the top of the soil cores was higher for the clear bulbs (49 C) than for white (46 C), green (41 C), yellow (39 C), red (39 C), or blue (35 C) bulbs. Thus the reduction in arthropod catch might be attributed to temperature or intensity rather than color. Greatest recoveries occurred under white light bulbs (Table 2), and we recommend that they be used in the extractor.

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